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SECTORAL TECHNOLOGY STRATEGY SERIES

No 9

The Canadian Forest-Products Sector

SECTORAL TECHNOLOGY STRATEGY SERIES

NO. 9 THE CANADIAN FOREST-PRODUCTS SECTOR

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Contents

Highlights v
Background to the Sectoral Technology Strategy Series viii
Commentary on the Sectoral Technology Strategy Series and R&D Targets ix
List of Sectoral Technology Strategy Series Reports xi
Acknowledgements xii

Introduction 1

Overview of the World Forest-Products Sector 2
- The Global Market 2
  - Paper and Paperboard 2
  - Market Pulp 2
  - Wood Products 3
- The Global Sector 3
  - Pulp and Paper 3
  - Wood Products 5

Overview of the Canadian Forest-Products Sector 6
- The Canadian Market 6
- The Canadian Sector 6
- International Comparisons in R&D and Technical Competence 12
- R&D Investments and Strategies of Canadian Firms 16

Opportunities and Challenges for the Canadian Sector 23
- Enhancing Technical Competence 23
- Technology and Market Opportunities 23
  - Wood Products 23
  - Market Pulp 24
  - Newsprint 24
  - Printing and Writing Paper 25
- A Daunting Challenge 26

Conclusion 28

Appendix: Framework for Technology Strategies 29

Notes 31

Tables and Figures

Table 1. World paper-grade woodpulp consumption 4
Table 2. Exports of forest products, by country (1987) 6
Table 3. Fifty largest forest-products companies in the world 10
Table 4. Canadian forest-products R&D spending (1987) 18
Table 5. Total contribution to R&D in forestry (1988) 19

Figure 1. Value added per employee, Canadian forest-products sector (1981-1986) 7
Figure 2. International comparisons of value added and exports in wood products (1980-1986) 8
Figure 3. International comparisons of value added and exports in pulp, paper, and products (1980-1986) 9
Figure 4. Paper to virgin pulp production ratios, selected countries (1980-1987) 9
Figure 5. Estimated corporate pulp-and-paper R&D expenditure, by country (1986) 13
Figure 6. Percentage of sales devoted to R&D, selected companies (1982-1989) 15
Figure 7. International comparisons of selected input costs (1987) 16
Figure 8. Number of employees doing in-house pulp-and-paper research in 13 Canadian forest-products companies (1980-1990) 20
Figure 9. Number of employees doing cooperative pulp-and-paper research in 10 Canadian labs and universities (1980-1990) 21
Figure 10. Total intramural R&D expenditures in Canadian forest-products companies (1981-1990) 21
Figure 11. Total intramural R&D expenditures by Canadian forest-products firms as percentage of sales 22

Highlights

- Canada's forest-products sector accounts for 20 per cent of Canadian manufacturing output and 3.6 per cent of gross domestic product. It is by far the most important net exporting sector, with foreign sales of $22.1 billion in 1990. It holds a 22 per cent share of the world trade in forest products.

- This striking success has been built on access to a vast quantity of high-quality raw material, low power costs, and investment in up-to-date equipment (most of which was purchased from other countries). Labour productivity showed impressive gains during the 1980s but remains below that in the United States.

- Projections for the next two decades suggest that the world market for forest products will expand greatly. But new producers are appearing, especially in Oceania and Latin America, with the competitive advantage of low-cost, high-quality, plantation-grown fibre.

- Increases in demand for forest products will be greater in the high-value end of the market, such as printing and writing papers and new wood products, than in commodities such as pulp, newsprint, and lumber that have been the focuses of growth in the Canadian sector during the past 40 years.

- The Canadian sector has lost much of its competitive edge, highlighted by the high Canadian dollar since 1986. It is undergoing a painful period of transition toward higher value-added products and environmentally benign operations. Continued high interest rates have taken their toll on reinvestment. Investments to meet environmental regulations will be heavy for the next five years, and there is a need to invest in new technology to recycle waste paper. This investment will meet market demands for recycled content in newsprint, without commensurate growth in paper consumption.

- With new pressures to shift emphasis from commodities to higher value-added products, there is a greater need for individual firms to develop their own product technologies. This pressure for innovation is occurring when economic conditions have led the industry to cut back on in-house research. Public pressure for better environmental practices and paper recycling also add to the need for R&D into new technologies.

- In the search for corporate profits and growth, the primary drivers of innovation and R&D in the sector are becoming increasingly complex. In the 1990s they are cost, environment, improved quality (especially uniformity), product differentiation, and recycling. The movement toward recycling has potentially serious implications, accelerating the loss of Canadian market share in North American and European newsprint and contributing to further threatening the survival of many small papermaking towns.

- Many Canadian forest enterprises are subsidiaries of foreign companies whose major R&D efforts are based outside Canada.

- The Canadian sector has not invested heavily in in-house proprietary R&D. In general, Canadian firms spend less than 0.5 per cent of their sales on R&D. Large U.S. firms invest 1 per cent of sales in R&D; firms in Europe and Japan spend close to the U.S. level.

- It is extraordinary that in a sector on which so much of Canada's creation of wealth depends, only two forest-products firms conduct in-house R&D on solid-wood products. Yet the light industrial and commercial construction markets in North America offer great potential, particularly if firms address the paucity of information in structural design engineering in wood.

- At present, about 40 per cent of R&D in the Canadian forest sector is performed in-house by private firms, 17 per cent by cooperative research institutions, and 43 per cent by governments and universities.

- Cutbacks in R&D by several Canadian firms during the recession of the past two years are of concern, particularly because it takes time to build good research teams and because of the need for innovation. Diminished cash flow and the high cost of capital impede product development and investment.

- In this sector individual Canadian scientists are highly creative but teamwork in the R&D system — though improving — is weak. Subsequent commercialization is poor, due in part to the lack of a vibrant machinery-manufacturing sector in Canada.

- The sector has focused on commodities rather than on the higher value-added products, whose development tends to be more research-intensive. It is imperative that the sector become more sensitive to the market by offering products that are better than or different from those of competitors and that respond to customer needs.

- With the recent support of the forest industry, the university training of employees in the Canadian sector is reaching a comparable level with those in other countries. However, technical training in Canada lags behind many nations. The lack of qualified forestry technicians makes it difficult to absorb new solid-wood technology, although absorbing pulp-and-paper technology is easier. The lack of qualified technicians also makes introducing modern machinery more risky and potentially less effective.

- The Canadian sector essentially purchases and imports its technology from equipment suppliers, who do much of the R&D required, although some R&D is also transferred from Paprican. As the world market demands wood and paper products that are of higher quality and more customized, however, so Canadian firms will require greater technological capabilities and more proprietary R&D. In part this R&D will provide information tailored to local conditions and improve Canada's ability to adopt and adapt new technologies.

- Relatively few Canadian foresters consider their province is doing a good job in forest management. Greater investment in forest research is required both to reflect the emerging goals of sustainable development of forests and to promote timber and non-timber values in forestry management.

- Pressure to protect and promote non-timber values will affect the sector's fibre supply and is contributing to a re-examination of land tenure systems.

- A priority is to create a cohesive research network, with more effective coordination and collaboration between the various research facilities.

- The need for management to attend to technological matters and related customer satisfaction will only be reinforced by a continuing strong Canadian dollar.

Background to the Sectoral Technology Strategy Series

In the emerging "new" economy of the 1990s, successful high-value businesses in advanced nations are being driven by innovation, propelled by spending on new products and processes. Their business strategies centre increasingly on specialized knowledge and skill in finding the right "fit" between their unique blend of core technologies and particular markets.

Where does Canada stand in this rapidly evolving new environment of changing linkages and relationships? The poor innovative capacity of Canadian industry has long been a concern of the Science Council of Canada, going back to its 1971 report *Innovation in a Cold Climate*. The Council re-emphasized this concern in 1988. It focused its attention on the potential for action at a sectoral level in its statement *A Sectoral Approach to Innovation*. It argued:

> There is growing recognition by industry and government in Canada of the key role played by technology and R&D in domestic and international competition. The Science Council considers that it is primarily the responsibility of industries to raise the degree of domestic technological sophistication and the level of R&D. Nevertheless, governments can help business to sustain long-term competitiveness both by building partnerships with individual firms and by generating consensus on the formulation of innovation strategies for the various industrial sectors. The intent is not for government to tell business what to do, but to facilitate business cooperation in a process of self-help. The process of building consensus on a strategy for a particular sector will involve close and on-going consultation with industries about the current role of technology and R&D in the sector, the opportunities foreseen, and the nature of the sources, stimuli, and forms of technological innovation. Obviously, to be successful, separate innovation strategies will be needed for each sector. The Science Council hopes that the process of building consensus will generate commitment and collective will concerning priorities, areas for cooperation, and agenda for action.

This statement proved to be an important step in the path that subsequently led the Council to undertake a major Sectoral Technology Strategy project.

In 1989, Industry, Science and Technology Canada, at a time of heightened concern for the state of Canadian competitiveness and serious questioning about the low level of Canada's gross expenditures on research and development as measured against other advanced countries, agreed to provide the main funding for this project. It also stipulated the selection of sectors on which it would like the project to focus.

Each report in this Sectoral Technology Strategy Series draws in part upon analyses commissioned by the Science Council of Canada from contractors, designed to reveal the key dynamics driving technological innovation in the sector and influencing company technology strategies. Each report has also benefited considerably from the comments and advice submitted by the many external reviewers from business, universities, and government, who are recognized in the Acknowledgements.

Commentary on the Sectoral Technology Strategy Series and R&D Targets

The Sectoral Technology Strategy Series has analysed 15 Canadian sectors. On the basis of this experience, the Science Council of Canada makes the following points with regard to Canadian R&D performance and the issue of setting sectoral R&D targets.

- Canadian firms, when grouped by sectors, generally perform much less R&D than their trade competitors. Using the indicator of R&D as a percentage of sales, Canadian firms undertake R&D at a rate about one-third to one-half the rate of their leading international sectoral competitors. The notable exception among those sectors analysed in telecommunications.

- In some product lines or specific technologies certain absolute threshold levels of R&D and capital investment must be reached if the effort is to be considered to have a chance of making a commercial payback. High thresholds are apparent in some parts of sectors such as telecommunications (central office switches), automotive parts ("Tier 1" supplier status), oil and gas (reformulated gasoline standards by refineries), and electronics (integrated circuit foundry). Such absolute thresholds cannot be clearly expressed as a percentage of sales.

- The reasons for the lower level of R&D spending by firms in most of the 15 Canadian sectors are: choice of business and technology strategy (which, in part, leave Canadian companies as essentially non-participants in many higher value-adding segments); the relatively small size of Canadian firms; the high absolute thresholds of R&D expenditure required to be a meaningful player, especially for innovative technology strategies; and the degree of foreign ownership of Canadian firms (especially important in the case of the automotive vehicles and parts sectors).

- The lack of R&D relative to other countries affects Canadian competitiveness, but it is only one of many factors, such as capital and labour costs, quality design, good marketing, and management, that interact to affect overall competitiveness. Nevertheless, the contribution of R&D, or more precisely, technology-based innovation, is becoming more pronounced throughout the global economy and Canada continues to fall behind. The low level of R&D is especially detrimental to the capacity of Canadian resource-based sectors to compete with higher-value, differentiated products, leaving them vulnerable to adverse shifts in costs beyond their control, such as a higher exchange rate.

- Major potential does exist for Canadian industry to make additional R&D investments. However, fulfilling this potential depends heavily on the vision and capability of management to make strategic use of technology, to speed the firms' innovation process, to work more closely with suppliers and "demanding customers" all the way to the end of the product chain, and to build core capabilities in incremental innovation and R&D. Canadian firms have not yet fully grasped the implications of the emerging new "lean enterprise" or "agile producer" strategy. To follow this new strategy involves seeking to offer maximum value to customers. It requires integrating the skills base of a knowledgeable workforce with flexible management structures that stimulate cooperative initiatives within and between firms to match customer needs.

- The dominant technology strategies being followed by Canadian firms in these sectors are of adopt and adapt. Innovation technology strategies are not very extensive (telecommunications is again an exception) and hardly any firms focus on breakthrough strategies to enhance competitiveness. Overall, these 15 sectors show little attempt at diversification out of existing product lines as opposed to making such products more efficiently.

- Governments can set sectoral R&D targets in the hope of stimulating enhanced industrial performance, shifts in business strategy, and greater commitment by the private sector to R&D. However, private sector R&D is only meaningfully undertaken in conjunction with a full complement of associated private and public sector actions ranging from improved design and production to finance and marketing. Doing more R&D will not be productive unless linked to a broader corporate technology strategy that is carefully designed to support the firm's business objectives. Otherwise, the corporation cannot, and will not, marshal the complementary investments required to reap the benefits of the R&D. It is the firm that must commit R&D resources.

- Setting sectoral R&D targets becomes more difficult as the boundaries between sectors are breaking down, through technological advances, regulatory change, and firm restructuring. Larger and more diversified firms that dominate modern industrial R&D perform R&D that might be allocated to any of several sectors. Examples include the textiles and materials R&D performed by large Japanese steel firms, the electronics R&D by automotive-vehicle firms, and the software R&D by telecommunications firms. Canadian governments have quite correctly encouraged higher levels of industrial R&D in Canada. In view of the rapid pace of scientific advances and technological change, plus the role of system interdependencies and synergies between technologies, setting R&D targets does not appear to be a task warranting the intensive effort, cooperation, and, ultimately, commitment that would be required by federal and provincial governments and private sector organizations.

List of Sectoral Technology Strategy Series Reports

No. 1 The Canadian Telecommunications Sector
No. 2 The Canadian Automotive-Parts Sector
No. 3 The Canadian Iron and Steel Sector
No. 4 The Canadian Automotive-Vehicle Sector
No. 5 The Canadian Oil and Gas Sector
No. 6 The Canadian Petrochemicals and Resins Sector
No. 7 The Canadian Banking Sector
No. 8 The Canadian Nonferrous-Metals Sector
No. 9 The Canadian Forest-Products Sector
No. 10 The Canadian Machinery Sector
No. 11 The Canadian Food and Beverage Sector
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No. 13 The Canadian Consulting-Engineering Sector
No. 14 The Canadian Electronics Sector
No. 15 The Canadian Computer Software and Services Sector

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Introduction

In Canada, forests are more than a source of lumber, pulp, and paper. They are also an important component of the landscape and ecology, a major source of Canada's comparative advantage and foreign earnings, and the economic backbone of about 350 communities. How well we nurture and exploit them will influence Canadian competitiveness in the forest-products sector, our standard of living, and the health of our environment.

How are we doing? Signs are that we are not doing as well as we need to, despite recent major improvements. The good news is that we have strengths that can be harnessed to grasp the opportunities emerging in global markets. The bad news is that we are slow to build and harness new strengths, and it is proving hard to establish consensus and commitment on developing the functions and human resources needed to rise to the challenges ahead. However, the sector is now passing through a major transition in management. As long as the investment climate improves, new managers in forest companies will have the opportunity to run and reshape their companies very differently from their predecessors.

Recession has severely hit earnings and constrained important capital expenditures. It has thus hurt the sector's capacity to respond to major changes in its fibre supply, environmental regulations, and demand, as markets move toward higher-quality and more differentiated products. For Canadian companies selling commodities such as lumber, newsprint, and wallboard mainly to the United States, the strong Canadian dollar, high interest rates without compensating incentives for capital investment, and the collapse of U.S. housing starts and newspaper advertising, have contributed to heavy cutbacks and vanishing profits. Does the sector show signs of being ready to rebound, at least as a low-cost producer, when markets improve? The signals are not encouraging for producers of standard commodities, particularly those with aging capital stock. And growing public demand for multiple use of forests is leading to increasing costs and uncertainty in the fibre supply.

The main objective of this report is to indicate the technology strategies of the leading forest-products firms and show how the sector performs in R&D compared with its main trade competitors. The report also outlines the major reasons for any differences and how they affect competitiveness.

Overview of the World Forest-Products Sector

The Global Market

Until recently the forest-products sector faced expanding global consumption and increasing global competition. Exports to most markets faced only modest tariff and non-tariff barriers, and sales were made on the basis of price, customer service, quality, and reliability of supply.

In recent decades the global sector has been relatively healthy. Earnings on capital have tended to be adequate, despite disruptive cycles. Profitability has usually shrunk, even vanished, when heavy new investment put too much capacity in the world market or when demand fell, as it has recently. But over the long term, demand has continued to increase, and projections point to a continued trend of increasing demand in the three major subsectors — paper and paperboard, market pulp, and wood products.

Consumption is expected to increase despite some areas of concern. Wood substitutes, such as metal studs, beams, and steel trusses, continue to threaten demand for many wood products, especially structural materials and packaging. An interesting example is the potential of "Superwood," a versatile wood substitute formed from previously unrecyclable plastic.

New forest products continue to be developed and may help Canada regain old markets or share in new ones. Innovation is taking place in reconstituted engineered wood products and wood-based composites; biotechnology and new pulping and bleaching processes are also driving much innovation. The sector is not well characterized as "mature," that is, it is still subject to significant innovations.[1] And although new wood substitutes are making inroads in the traditional markets for wood and paper, environmental concerns are posing major problems, including the problem of replacing disposable plastics and materials such as polystyrene, although technological responses such as biodegradable plastics are appearing.

Paper and Paperboard

This subsector consists of newsprint, printing and writing (P&W) paper, and other paper such as that used for packaging, construction, wallpaper, and tissues. Over the past two decades world production of paper and paperboard has been remarkably steady. Woodbridge, Reed and Associates (WRA) project a continuing steady increase in the worldwide use of paper and board.[2]

The highest rates of growth are expected in the newly developed countries, as their literacy rates and incomes improve. However, in absolute terms, most of the growth is likely to occur in North America, Europe, and Japan.

The growth in P&W papers has been substantially greater than that of newsprint and other papers during the past two decades. This is a result of demand from the advertising and office sectors, which account for 80 to 90 per cent of P&W paper use. Because this trend is expected to continue, WRA foresees printing and writing paper as the fastest-growing category.

P&W papers are not traded internationally to the same extent as newsprint is, although in recent years Western Europe has exported to the United States (mainly mechanical fibre-based products).

Market Pulp

The market-pulp business is highly cyclical. It enjoys periods of prosperity and growth but slumps during downturns because of its marginal role in supply. The Norscan countries (Canada, the United States, Norway, Sweden, and Finland) are the world's major producers of market pulp.

The huge expansion that is expected in world demand for paper and paperboard will generate a commensurate increase in the need for pulp and recycled fibre. In 1986, demand for 203 million tonnes of paper and paperboard required 137 million tonnes of paper-grade pulp (the balance came from recycled paper and a small proportion from non-wood fibres). Most of it came from the Norscan countries — more than 89 per cent of the world's bleached softwood kraft pulp (BSKP) and 47 per cent of bleached hardwood kraft pulp (BHKP). By 2010, even after taking into account enhanced recycling, more than 215 million tonnes of paper-grade pulp will be needed.[3]

It is expected that integrated and affiliated pulp-and-paper operations will increase in importance over the next two decades. Although market pulp accounted for 21 per cent of the pulp supply in 1986, WRA projects that this will fall to 19 per cent by 2010.

Absolute demand for BSKP will likely increase, but it is expected to lose market share to BHKP and mechanical pulp grades. Canada has a particularly strong presence in BSKP and mechanical pulp grades.

Wood Products

In 1985, world lumber production totalled 463 million cubic metres. Of this, 75 per cent was softwood and 25 per cent hardwood. By 2010, production will likely increase by about one-third.[4] The share of hardwood lumber is likely to rise to about 28 per cent. Over the same period, world lumber trade is projected to increase from 86 million cubic metres to about 125 million cubic metres, with hardwood increasing from 14 to 16 per cent of the total.

Production of panelboard — reconstituted board as well as plywood — is projected to increase by nearly 60 per cent during this period. The major growth will be in reconstituted board. A similar trend is foreseen in world exports of panelboard. In 1985, these were 18.9 million cubic metres (55 per cent reconstituted, 45 per cent plywood); in 2010 they are projected at 30 million cubic metres.

The Global Sector

Pulp and Paper

Over the next 20 years new suppliers will emerge in the world pulp-and-paper industry, especially suppliers of lower-priced grades of paper and paperboards and market pulps, who have access to lower-cost fibre grown on plantations. Also, the trend toward integrated and affiliated pulp-and-paper operations will continue.

Increasing the world's production of paper and paperboard over the next two decades will require increased production of raw materials. Production will come not only from woodpulp, but also from other sources of fibre, including recycled paper, non-wood fibres such as reeds or bamboo, and small volumes of agricultural residues.

Technological changes will affect the volume and grades of woodpulp used to make paper. Thus there will be an increase in the use of higher-yield (that is, mechanical) pulps and hardwood kraft pulps. Also, by using more recycled paper and more filling and coating agents, the sector will likely marginally reduce the average volume of woodpulp consumed per tonne of paper produced.

Kraft pulps will continue to be used more than other pulps in paper production. However, the use of BHKP has been increasing faster than other grades of pulpwood and will likely surpass the use of softwood kraft by the end of this decade (see Table 1).

Table 1. World paper-grade woodpulp consumption (million tonnes)

				Volume change		Average annual growth (%/yr)	
	1985	1995	2000	1985-1995	1995-2000	1985-1995	1995-2000
Bleached kraft							
Softwood	25.1	34.4	38.9	9.3	4.5	3.2	2.5
Hardwood	21.1	33.1	39.2	12.0	6.1	4.6	3.4
Sulphite	12.4	9.4	9.2	(3.0)	(0.2)	(2.7)	(0.4)
Unbleached kraft	33.1	36.9	39.9	3.8	3.0	1.1	1.6
Semichemical	7.2	8.6	9.4	1.4	0.8	1.8	1.8
Total chemical	98.9	122.4	136.6	23.5	14.2	2.2	2.2
Mechanical	30.5	38.4	42.9	7.9	4.5	2.3	2.2
Total woodpulp	129.4	160.8	179.5	31.4	18.7	2.2	2.2

Source: Woodbridge, Reed and Associates

A major reason for this increase is the availability of low-cost hardwood fibre from eucalyptus plantations in the Iberian Peninsula and Latin America, especially Brazil. Eucalyptus trees are ready for cutting in only seven to 10 years. By contrast, Canadian softwood species take 50 to 70 years to mature, although experimental work on fast-growing aspen poplar shows promise. And eucalyptus also has characteristics that make it desirable for some kinds of paper. New Zealand and Chile are also producing low-cost fibre from softwood plantations.

Technological changes in pulp production are also important. Mills that use thermomechanical pulps (TMP) and chemi-thermomechanical pulps (CTMP), developed over the last decade, recover more fibre than the kraft mills that have been the backbone of Canada's market-pulp industry. Initially TMP consisted only of softwood fibres, but the new CTMP process can accept some hardwoods. This means that mixes such as spruce and aspen can be used. The new processes require a great deal of electrical power. Regions that have lower power costs and access to fibre resources such as aspen (previously considered undesirable or uneconomic) will now have advantages for producing high-quality, bleached, high-yield pulps.

Most high-yield pulps are currently produced in the Norscan countries. Even though the technology is available, the extensive power needed to produce these pulps may preclude or inhibit other European nations and Asia from their production. At present, Canada accounts for about 59 per cent of world capacity for bleached CTMP market pulp, Sweden 22 per cent, Norway 9 per cent, New Zealand 5 per cent, and Finland 4 per cent.

Of particular interest to Canada, over the long term BSKP is projected to lose market share and BHKP and mechanical pulp to gain. Unbleached kraft and sulphite are likely to decline.[5]

North America will continue to be the largest producer of woodpulp. However, major production is projected in Latin America because of the availability of low-cost industrial roundwood from plantations — notably hardwood in Brazil and softwood in Chile.[6] Greater production is also

likely in Europe — hardwoods from Spain and Portugal and softwoods from northern Europe — and in the Asia-Pacific region (mainly from maturing plantations in Oceania). Future production in what was formerly the Eastern Bloc is less easy to forecast, because of the vast economic changes sweeping through the region. There is potential for production from the Soviet Union to increase, mainly from natural forest, but the infrastructure to accomplish this is, at present, lacking.

Of these regions, North America, Latin America, and Scandinavia are likely to increase production of woodpulp faster than consumption.

A huge increase in the volume of pulp exports from Canada is unlikely. WRA forecasts that Canadian and Scandinavian exporters will lose market share. Canada's share of the world export market for pulps is likely to go from 30 per cent (6.4 million tonnes) in 1986 to 27 per cent (eight million tons) in 2010. In the same period, the Nordic share of exports will drop, and non-Norscan exports will rise.

Wood Products

Because world demand for wood products is expected to increase by a volume of one-third between 1985 and 2010, none of the world's major producers will have to reduce production. However, there are likely to be shifts in the market share held by the various producing regions.[7] Canada will probably retain its 12 per cent of the world market, but only if it raises its silviculture budgets and addresses issues such as technology training, changing public values, and responsiveness to customer needs.

World lumber trade will likely increase substantially, but Canada's share will drop from 45 per cent to 37 per cent, although the volume of exports will increase.[8]

Softwoods and hardwoods, in general, satisfy different lumber markets, although there are markets in which they compete. Canadian hardwoods are not a major source of lumber in the world. In 1986, about 29 per cent of Canadian softwood lumber shipments were consumed domestically. Most of the remainder went to the United States, where Canada for many years held 30 to 33 per cent of the market, but recently slipped to 27 to 28 per cent.

Both production and consumption of softwood lumber are concentrated in the Norscan countries, the Soviet Union, elsewhere in Europe, and Japan. Of these, Canada, Scandinavia, and the Soviet Union are exporters; the United States, the rest of Europe, and Japan are importers.

World production of panelboard, particularly reconstituted board, is expected to increase substantially.[9] In 1985, the United States dominated the production of panelboard with 28 per cent of the market; by 2010 this will likely decrease to 23 per cent. Production increases will come mainly from tropical countries and the Soviet Union. Canada is likely to hold its present share of 5 per cent, thanks to competitive advantages in its fibre base and technological skills, and the strength of its established market position and distribution system.

Overview of the Canadian Forest-Products Sector

The Canadian Market

Canada's forest-products sector supplies about 90 per cent of its own domestic market, yet still exports 80 per cent of its shipments. Most exports go to the United States, although Canada has substantial sales of market pulp in Europe and Japan. In 1990, exports were worth $22.1 billion, which makes the sector by far the leading net exporter and a major part of the Canadian economy. Forest products account for more than 20 per cent of Canadian manufacturing output and for 3.6 per cent of Canadian gross domestic product. Directly and indirectly, the forest sector accounts for one of every 14 jobs in Canada.

The Canadian Sector

The Canadian forest-products sector is highly productive and has a strong, albeit recently diminishing, position in international markets. Productivity has improved in all areas but logging (Figure 1). Labour productivity, measured by the average annual rate of change in output per hour, rose by 3.5 per cent in the wood subsector and 2.5 per cent in the paper subsector in 1981-1987. The average rise in productivity for all Canadian manufacturing was 2.5 per cent.

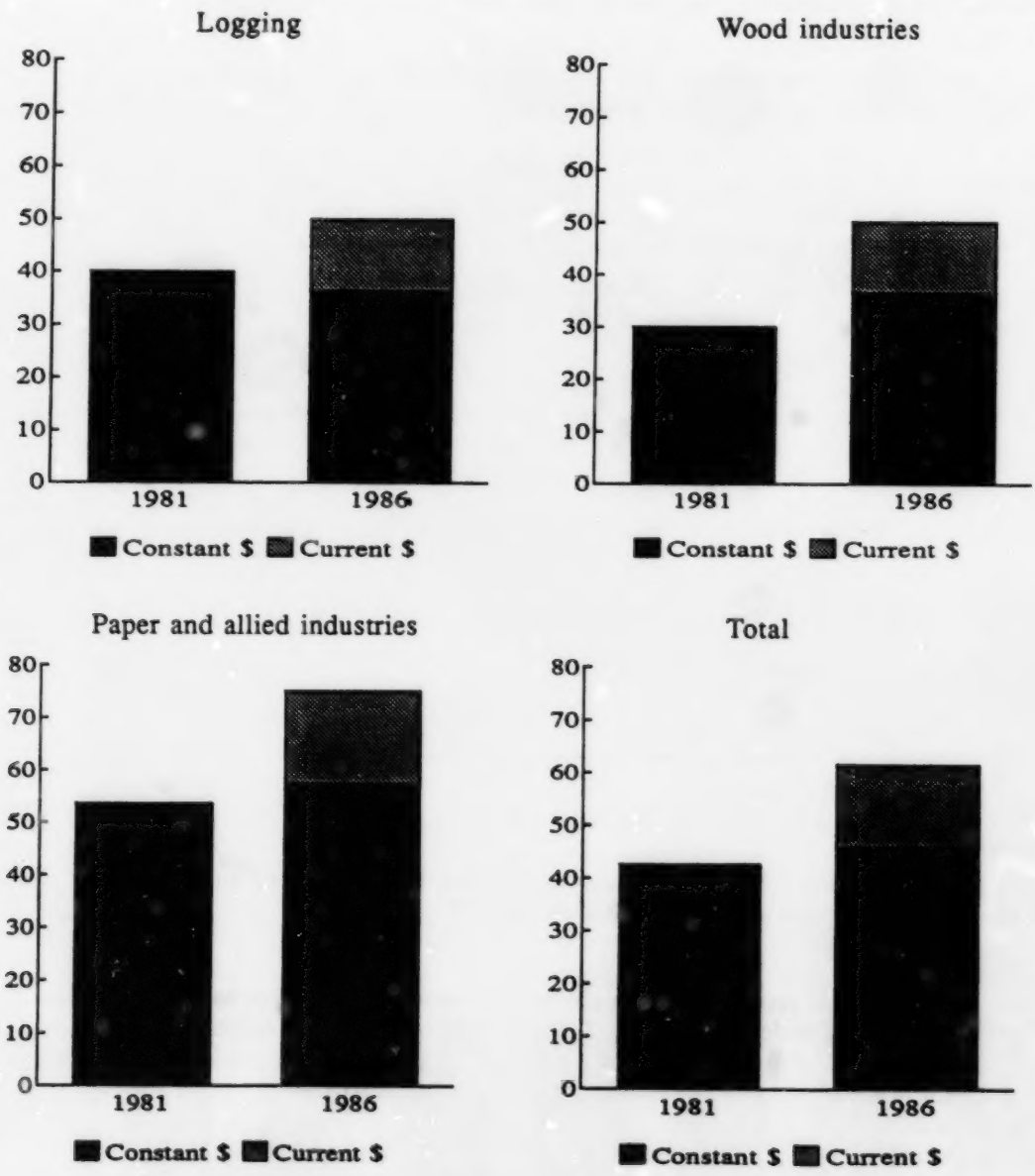
Table 2 reveals Canada's relative dominance of world trade in forest products — 60 per cent of newsprint, 43 per cent of softwood lumber, and 34 per cent of wood pulp. In 1990 Canada exported $15.2 billion of pulp and paper and $5.6 billion of lumber. In the world export market for forest products, the next largest players, in order, are the United States, Sweden, Finland, and the Soviet Union.

Table 2. Exports of forest products, by country (1987) (C$ million)

Country	Softwood lumber		Woodpulp		Newsprint		Other		Total	
	$	%	$	%	$	%	$	%	$	%
Canada	5 745	43	5 473	34	6 029	60	3 994	7	21 241	22
U.S.	1 128	8	3 062	19	278	3	6 365	11	10 833	11
Sweden	1 548	12	2 147	13	1 290	13	4 985	9	9 664	10
Finland	1 241	9	1 166	7	988	9	5 985	10	9 380	10
U.S.S.R.	1 296	10	621	4	204	2	1 866	3	3 987	4
Other	2 429	18	3 714	23	1 314	13	34 381	60	41 818	43
World total	13 387	100	16 183	100	10 103	100	57 576	100	96 923	100

Source: Food and Agriculture Organization and Statistics Canada

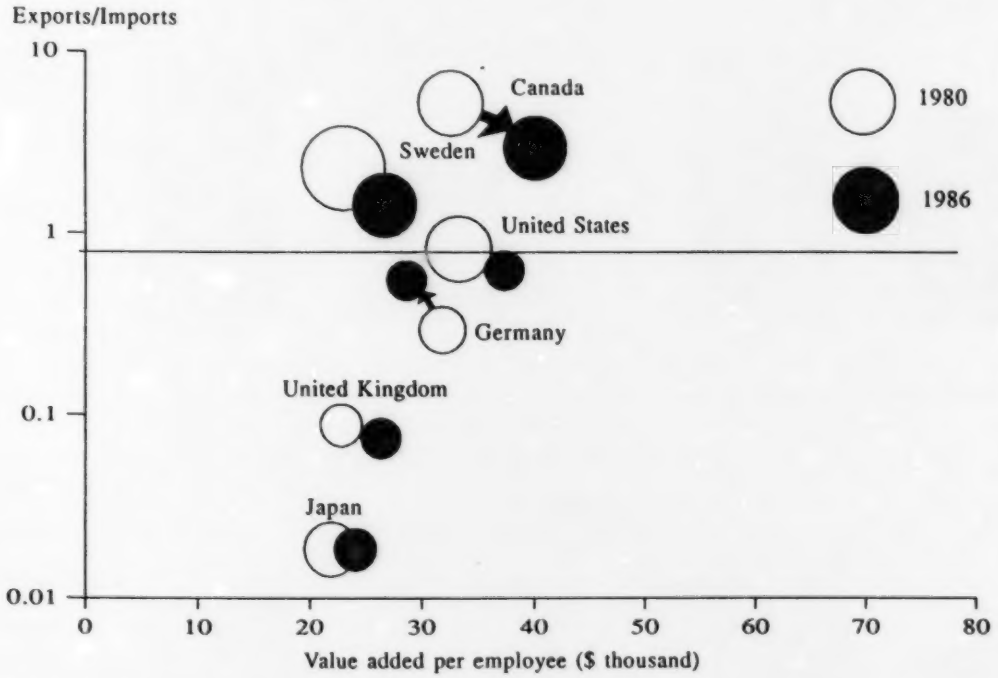
Figure 1. Value added per employee, Canadian forest-products sector (1981–1986) (C$ thousand)



Source: Canada Consulting Cresap analysis of Statistics Canada data

Despite recent high interest rates, a relatively high Canadian dollar, and worldwide overcapacity in pulp and newsprint, Canada's competitive position in export markets should continue to be strong. Of the major producers of wood products, Canada not only has the largest share of world exports, but also has made substantial increases in value added per employee (Figure 2).

Figure 2. International comparisons of value added and exports in wood products (1980–1986) (1986 U.S.$ at purchasing power parity)

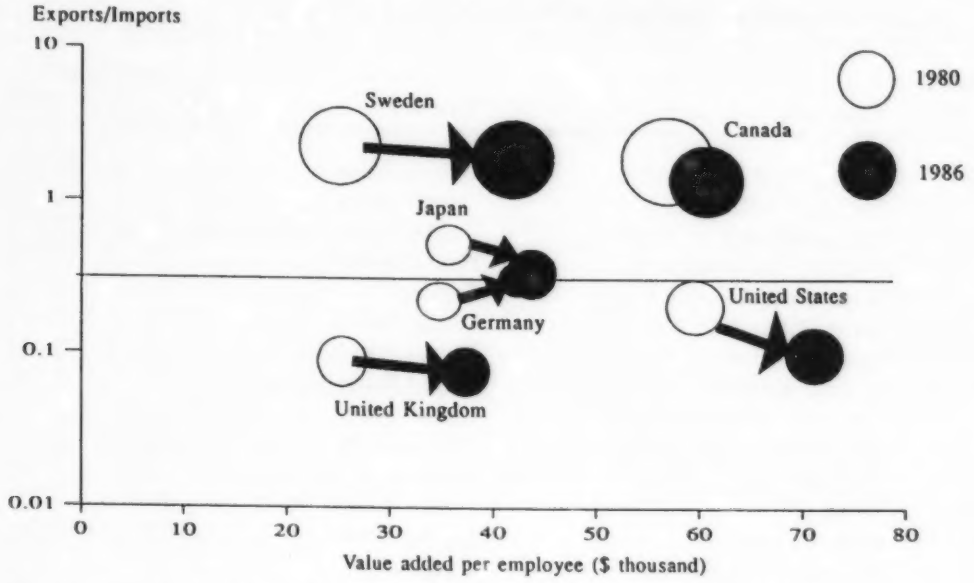


Source: Canada Consulting Cresap analysis of OECD and United Nations data
Note: Circle area is proportional to contribution to GDP

However, in pulp and paper, Canadian gains in value added per employee have been smaller than, in particular, those of Sweden and the United States. Canada nonetheless retains a strong competitive position, second to Sweden in net exports of pulp, paper, and paper products, with Japan a distant third. Productivity in the Canadian pulp-and-paper subsector is second only to that of the United States (Figure 3).

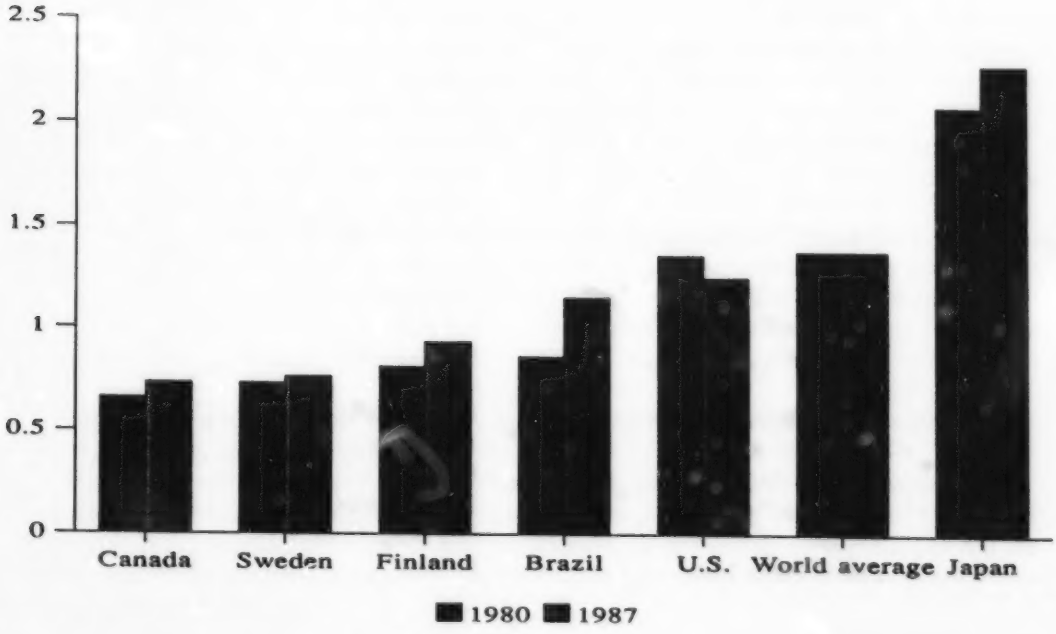
The organization of the Canadian forest-products sector is changing, but Canada lags in integrating pulp-and-paper operations, compared with other leading nations. It also has a low ratio of paper to virgin pulp production (Figure 4). Canada's leading companies are integrated, diversified, and relatively large by world standards. However, the three largest forest-products companies in the world and eight of the largest 10 are American. Canada's largest forest-products company, Noranda Forest, ranked 14th in the world (by total sales), MacMillan Bloedel, 23rd, Abitibi Price, 25th, and Canadian Pacific Forest ranked 31st in 1989 (Table 3).

Figure 3. International comparisons of value added and exports in pulp, paper, and products (1980-1986) (1986 U.S.$ at purchasing power parity)



Source: Canada Consulting Cresap analysis of OECD and United Nations data
Note: Circle area is proportional to contribution to GDP

Figure 4. Paper to virgin pulp production ratios, selected countries (1980–1987)



Source: Woodbridge, Reed and Associates
Note: All countries increased their paper and board production in absolute terms over the period

Table 3. Fifty largest forest-products companies in the world (U.S.$ millions)

Rank 1989	Rank 1988*	Company	Country	Total Sales 1989	Total Sales 1988*
1	2	International Paper	United States	$11 378	$9 578
2	3	Georgia-Pacific	United States	10 171	9 509
3	1	Weuyerhaeuser	United States	10 106	9 328
4	4	Fletcher Challenge (1)	New Zealand	7 171	5 448
5	5	Stora Group	Sweden	6 551	6 514
6	8	James River	United States	5 872	5 098
7	6	Kimberly-Clark	United States	5 734	5 394
8	14	Stone Container	United States	5 330	3 743
9	7	Champion International	United States	5 163	5 129
10	9	Scott Paper	United States	5 066	4 726
11	12	Oji Paper (2)	Japan	4 685	4 007
12	10	Mead	United States	4 612	4 463
13	11	Boise Cascade	United States	4 338	4 095
14	*13*	*Noranda Forest*	*Canada*	*4 111*	*3 830*
15	17	Jujo Paper (2)	Japan	3 886	3 350
16	15	Great Northern Nekoosa	United States	3 863	3 566
17	16	Svenska Cellulosa	Sweden	3 861	3 416
18	21	Sanyo-Kokusaku Pulp (2)	Japan	3 441	2 903
19	20	Honshu Paper (2)	Japan	3 361	2 968
20	18	Modo Group	Sweden	2 915	3 199
21	32	Amcor (1)	Australia	2 855	2 113
22	34	Daishowa Paper (2)	Japan	2 836	2 276
23	*24*	*MacMillan Bloedel*	*Canada*	*2 765*	*2 659*
24	23	Union Camp	United States	2 761	2 660
25	*22*	*Abitibi-Price*	*Canada*	*2 751*	*2 685*
26	19	Bunzi PLC	United Kingdom	2 690	3 111
27	26	Kymmene	Finland	2 627	2 474
28	41	Wiggins Teape	United Kingdom	2 600	2 587
29	28	Enso-Gutzeit	Finland	2 504	2 337
30	29	Buhrmann-Tetterode	Netherlands	2 430	2 285
31	*27*	*Canadian Pacific Forest*	*Canada*	*2 429*	*2 442*
32	35	Westvaco	United States	2 284	2 134
33	*33*	*Domtar*	*Canada*	*2 124*	*2 030*
34	36	Temple-Inland	United States	2 124	2 017
35	43	Rengo (2)	Japan	2 113	1 832
36	42	Metsa-Serla	Finland	2 021	1 812
37	39	Louisiana-Pacific	United States	2 010	1 799
38	37	PWA	Fed. Rep. Germany	2 005	1 954
39	47	United Paper Mills	Finland	1 968	1 503

Continued on next page

Table 3–*Continued*

Rank 1989	Rank 1988*	Company	Country	Total Sales 1989	Total Sales 1988*
40	30	Jefferson Smurfit (3)	Ireland	1 941	1 755
41	44	Willamette Industries	United States	1 892	1 716
42	n/a	Mitsubishi Paper Mills	Japan	1 818	1 409
43	48	Taio Paper	Japan	1 796	1 525
44	31	Feldmuhle	Fed. Rep. Germany	1 653	2 281
45	49	Bowater	United States	1 450	1 410
46	45	La Cellulose Du Pin	France	1 436	1 642
47	n/a	Federal Paper Board	United States	1 310	1 117
48	n/a	KNP	Netherlands	1 278	1 289
49	n/a	Potlatch	United States	1 228	1 084
50	*n/a*	*Fletcher Challenge*	*Canada*	*1 185*	*1 196*

Source: Price Waterhouse

*The 1988 sales revenues have been restated by companies where appropriate to reflect acquisitions, divestitures, and restructurings; consequently, 1988 reported sales may be inconsistent with 1988 rankings.
(1) Fiscal year ended 30 June 1989
(2) Fiscal year ended 31 March 1989
(3) Fiscal year ended 31 January 1989

The growth of larger firms (through internal growth, mergers, and acquisitions) has been a feature of the industry throughout the world in the last decade. In 1990 three Swedish companies together accounted for three-quarters of the total output of the Swedish forest industry. Larger companies are also a feature in Canada — in 1988 and 1989 alone, eight major mergers or acquisitions occurred. Seven Canadian corporate groups now each have sales of more than $1 billion, still a small amount by world standards.

In the last 40 years, the Canadian sector's remarkable growth has been achieved in part by investing in world-class mills that are highly productive and competitive. The move toward larger companies has been partly fuelled by opportunities for economies of scale and producing more efficient operations through cooperation between forest-products firms. But a problem remains with the large percentage of small-scale, older facilities in operation — a problem not found in competitor countries.

Over the last 40 years, the Canadian industry has focused on producing more softwood lumber, market pulp, and newsprint.[10]

About 453 million hectares of Canada are forested, and about 233 million hectares are considered commercial. The annual harvest of trees is about 175 million cubic metres, of which close to 70 per cent is for building products — lumber, waferboard, and plywood. The leftover and the remaining roundwood are used to produce about 8 million tons of market pulp and 16 million tons of other pulp-and-paper products.

In recent decades there was rapid growth in U.S. demand for construction-grade softwood lumber, and Canada had secured one-third of this market by 1985. Canada's high-quality, low-cost fibre was a factor, and so were the Canadian achievements in manufacturing and productivity, such as small-log processing and large, low-unit-cost mills. Canadian firms became leaders in sawmilling and made some notable technological advances, such as the Chip'n'saw. However, Canada's very successful advance into U.S. markets led to American complaints that (in Canada) Canadian companies were paying lower stumpage fees than U.S. companies. The result was a controversial memorandum of understanding (MOU) dealing with the export of Canadian softwood lumber. In combination with the high Canadian dollar since 1986, the MOU has helped reduce Canadian competitiveness in the U.S. lumber market. The Canadian share has slipped to about 27 per cent.

Canada's production of softwood kraft market pulp grew well when it had few global competitors. World papermakers have traditionally paid a premium for the strength and brightness of northern BSKP. This, added to the availability of excellent, untapped softwood resources, made Canada the world's single largest supplier of softwood kraft market pulps, and the supplier of 95 per cent of U.S. imports. However, although exports of pulp to the United States continue to increase, Canada is losing market share. Several mills are small, old, and inefficient; the average age of Canada's pulping facilities, particularly in eastern Canada, is higher — in some cases twice the average — than those of its major competitors. About half of Canada's pulp exports now go to non-U.S. markets. In the next two decades, producers of market pulp are expected to lose ground in the world market to integrated paper manufacture.

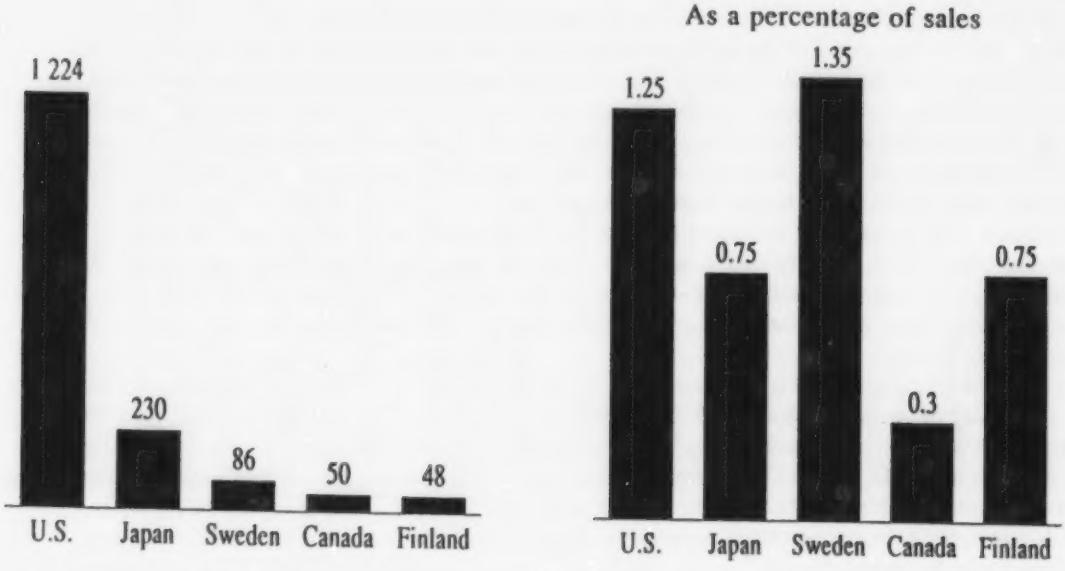
Newsprint, the third area of Canadian growth, has a long history of expansion. Over the past 40 years, it has been boosted by strong U.S. and offshore demand, based on Canada's ability to supply a high-quality product at a competitive price. Canada's abundance of low-cost energy has also contributed to the growth of newsprint. Canada retained a fairly stable share of more than 60 per cent of the U.S. market in the 1970s but dropped to 56 per cent by 1989.

The Canadian sector has benefited from access to vast areas of indigenous raw material. It has profitably served export markets with basic and intermediate goods, such as construction lumber and market pulp, as well as some relatively lower value-added paper grades, such as newsprint. Now there is a strong drive to improve quality, using raw materials and other resources much more productively. At a time when technological change is sweeping the world industry, and new market challenges are coming from substitute products and alternative production sources, Canada must produce higher-quality products if it is to remain competitive.

International Comparisons in R&D and Technical Competence

The search for profits and growth has made R&D and innovation in forest products more complex. In the 1960s and 1970s cost was the primary factor. In the 1980s cost, environment, quality, and product differentiation were equally important. In the 1990s there is an additional factor — recycling. Canada's main competitor in forest products is the United States. Estimated corporate R&D spending in that country exceeds 1 per cent of sales, which is less than in Sweden but more than in Finland and Japan (Figure 5).[11] American firms are increasingly focusing on advanced technologies such as automation, sophisticated research into process analysis, and new products especially in P&W papers and consumer products.

Figure 5. Estimated corporate pulp-and-paper R&D expenditure, by country (1986) (U.S.$ millions, at purchasing power parity)



Source: Woodbridge, Reed and Associates; Faculty of Forestry, University of British Columbia

The United States has a considerable lead in the total expenditures devoted to R&D in pulp and paper. New pressures for innovation have arisen in the United States (and in Canada) from four major factors:[12]

- new competition from tropical countries with low-cost fibre, which has eroded the low-cost position of southern pine and will increasingly substitute for northern kraft;
- environmental concerns, which have grown dramatically;
- recent decisions to preserve the habitat of the spotted owl, which have greatly reduced the allowable cut in the old-growth forests of northern California, Oregon, and Washington; and
- recycling, demanded by consumers and mandated by state and local governments, which will create demands for capital investment in de-inking plants.

In recent decades, Sweden has been a world leader in technology for the forest-products sector.[13] In the 1960s, predictions for the sector's future were ominous. Timber was becoming scarce and expensive, labour and energy costs were high, and environmental regulation had become extremely stringent. In response, the Swedes invested heavily in R&D to optimize yields. They pioneered the commercialization of high-yield CTMP technology that produces a better "furnish" than mechanical pulping; they also improved sawmilling productivity.

Much of the basic invention and innovation on which the Swedes built was created in Canada or had its origins here. Patents for some important facets of modern pulping are held by Canadian Pacific Forest Products and Abitibi-Price Inc. However, the Swedes had a major advantage in the lack

of synergy in Canada between a vibrant machinery manufacturer and the pulp-and-paper subsector. (See also Science Council of Canada Sectoral Technology Strategy Series, No. 10: *The Canadian Machinery Sector*.) Swedish forest-products and forest-equipment companies consolidated and vertically integrated. The result is that Sweden today has more pulp-and-paper capacity than 15 years ago, and even with higher timber, wage, and energy costs, remains internationally competitive. Finland, facing similar conditions, has also proved innovative and has invested heavily in technology development.

Similarly, Japan is faced with high energy and labour costs, a scarcity of fibre, and a demanding consumer market. For decades, Japan has imported raw materials — logs, timber, wood chips, and pulp — and has become a world leader in recycling technologies. One of Japan's most important forest-products companies, Daishowa, imports 50 per cent of its raw materials. Daishowa, along with Japan's other major companies, safeguards its access to fibre with considerable investments offshore, including recent major investments in the North American sector. A further strategy of the Japanese industry is to focus on higher value-added products.[14]

Canada's strong position in export markets for forest products has been achieved despite relatively little R&D. The industry has focused primarily on producing commodities rather than higher value-added products, whose development tends to be more research intensive. Moreover, many Canadian pulp-and-paper enterprises are subsidiaries of foreign companies whose major R&D efforts are based outside Canada.

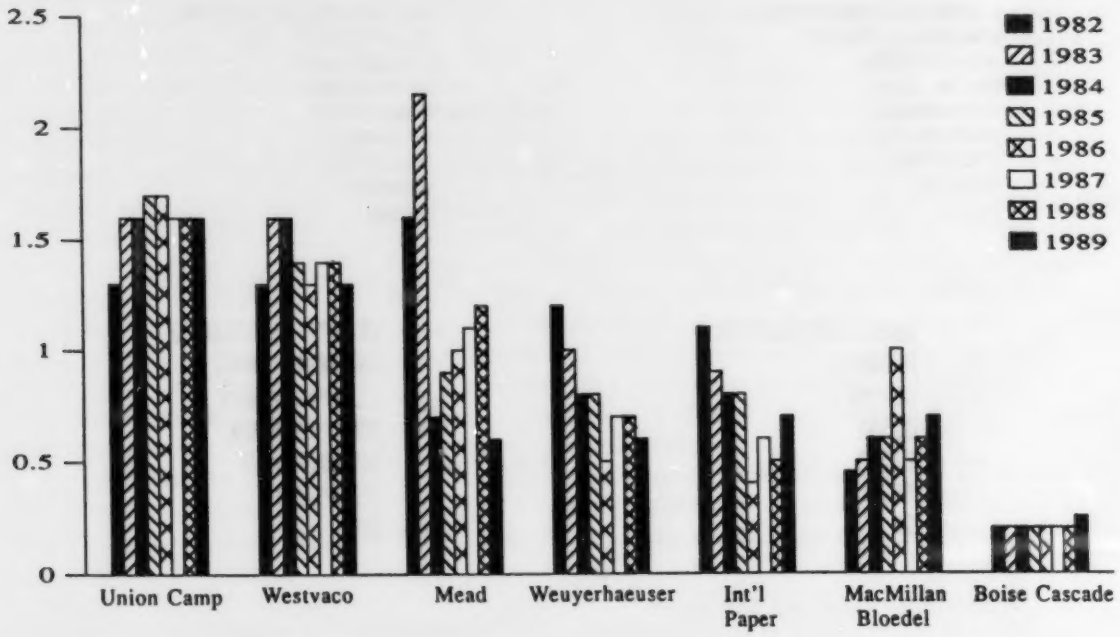
Canada's leading forest-products company in R&D is MacMillan Bloedel, which spent an unusual 1 per cent of sales on R&D in 1986 but only about half that level during most of the 1980s. By contrast, as Figure 6 shows, several big U.S. companies have recently spent from 1 per cent to 2 per cent of sales on R&D. Union Camp, for instance, averaged about 1.5 per cent in the 1980s and raised its sales and assets about 18 per cent annually. In 1989 it spent U.S.$47.6 million on R&D, much of it on chemical research. Another example, Mead, spent much of its major R&D budget on computer and printing technologies.

Another forest-products firm with a high investment in R&D is the Swedish company Stora, the largest forest-sector enterprise in Europe. Stora employs more than 21 000 people, 4000 of whom work outside Sweden.[15] By 1989 it had raised its number of R&D employees to 230, about one-sixth the number of employees in pulp-and-paper research in Canada. Stora's increased R&D has been directed toward product development, particularly in absorbent materials. Its process research has focused on ultra-high-yield pulps and CTMP. It has also increased its research into environmental safety, especially substitutes for chlorine bleaching. Stora has been acquiring forest-products companies in Europe, pursuing a threefold objective of growth, vertical integration, and securing access to the European Economic Community. Stora's business strategy is to focus on pulp and paper, selling off non-pulp-and-paper product businesses.

Canada's spending on R&D as a proportion of sales has regularly been about half that of the United States, Sweden, Finland, and Japan. Canada's technical competence in forest products is weak in another respect. A 1988 report for the Canadian Pulp and Paper Association shows that Canadian engineers and scientists in this sector are less qualified than their counterparts in the Nordic countries and Germany.[16] Moreover, during downturns, the Canadian sector tends to cut costs by reducing technically trained staff through layoffs, early retirements, and hiring freezes — a shortsighted approach that does not happen in the Nordic countries and Germany.

European forest-products firms have better-trained people throughout their organizations. There are more graduates in line management, and senior hourly and operating personnel have more formal training, such as a two-year diploma in pulp and paper. The result is that Canada's technical competence lags behind that of Sweden, Finland, Norway, and Germany.

Figure 6. Percentage of sales devoted to R&D, selected companies (1982–1989)

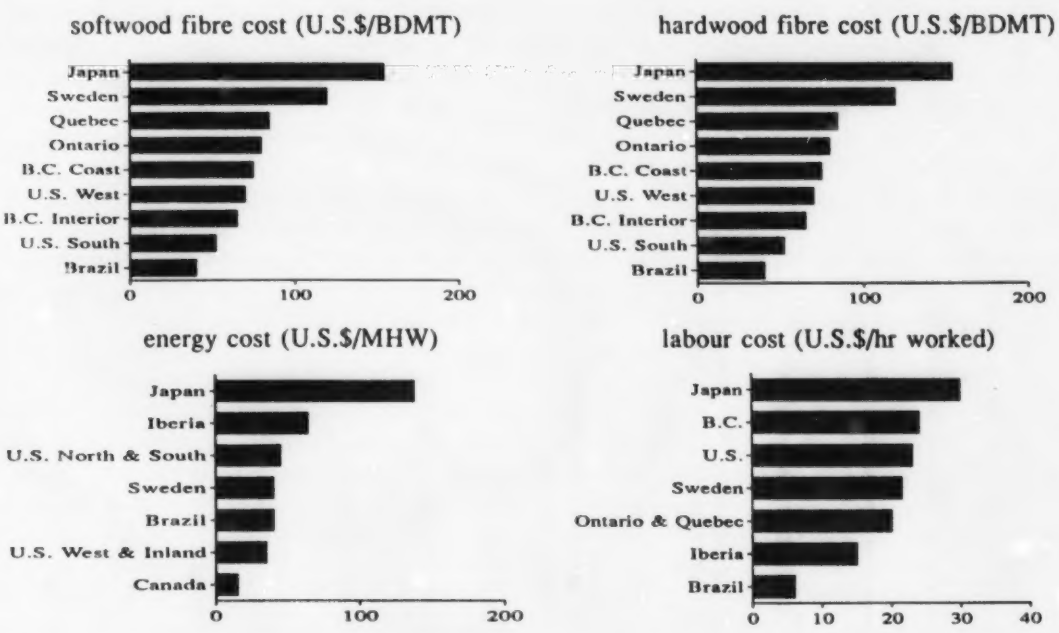


Source: MacMillan Bloedel

Clearly, many Canadian companies have been reasonably successful using purchased technology. They have not needed the same intensity of R&D as companies in other countries to compete profitably. However, they have not proven very profitable: the return on assets after tax of many Canadian forest-products firms during the 1980s was lower than that of their main U.S. competitors and less than the return on Canada Savings Bonds. Canadian firms have had the great advantage of a low-cost, high-quality source of fibre combined with low energy costs (Figure 7). The range of Canadian products has emphasized the low end of the market — pulp, newsprint, and construction lumber — rather than high value-added products. Canadian firms have been integrating pulp into paper production but at a much slower pace than those in other nations. To help stimulate further technical competence and R&D, such integration may prove important: a major portion of Canadian sales have been into cyclical commodity markets, a situation that hinders existing and new R&D investment.

Dependence on a strategy of purchased technology has important limitations as well as advantages in this sector. The adoption of new technology by the forest-products industries tends to be slow, in part because the essential scientific knowledge for the success of new technologies seems to

Figure 7. International comparisons of selected input costs (1987)



Source: Woodbridge, Reed and Associates

grow slowly. A recent assessment[17] in the United States found that the major reasons for the slow adoption of some new technologies in forest products are:

- most technologically relevant information is highly fragmented;
- information on any given use is expanded very slowly;
- feedback loops from use and experience are much less significant as diffusers of useful information than is the case in other industries; and
- over a range of productive uses, scientific theory, although valuable, cannot provide information tailored to local conditions.

Speeding up the adoption process can contribute to productivity and cost competitiveness; however, this sector requires proprietary R&D to provide information tailored to local uses, thus enabling firms to adopt and adapt new technologies.

R&D Investments and Strategies of Canadian Firms

The strategy of purchasing technology developed outside Canada may be hard to sustain if Canadian firms are to retain their competitiveness. Canadian forest-products firms have invested heavily in advanced machinery and equipment, but the suppliers — mostly offshore — have done most of the R&D. Canadian firms have adopted modern technology conservatively; this, combined with access to R&D from the sector's three cooperative R&D laboratories, has deterred or substituted for the needed

investment in in-house research.[18] As new conditions pressure firms to shift production from commodities to higher-value commodities and speciality products, there will be greater need for firms to develop their own product technologies. Adding to this pressure for enhanced in-house research and cooperative R&D are environmental regulations and consumer pressure for more paper recycling. The sector also has to attend to technology issues that emerge as non-tariff barriers affect access to markets, such as the ban by many European countries on PCP used to control sapstain and fungus.

Some Canadian companies do undertake R&D; however, they currently spend, on average, only half as much per dollar of sales as their foreign competitors. They have mostly customized their research programs to address local conditions and their strategy of slowly adopting and adapting the technology of others.[19] Thus, Abitibi has focused on adopting and innovating process technology and plans more emphasis on recycling. Canfor is increasing its focus on wood products and pulp-and-paper research and has, for instance, developed Ecobrite, an environment-friendly anti-sapstain lumber spray now used in 40 Canadian sawmills. Domtar's research is still primarily aimed at adopting and adapting process technology. It plans to shift its efforts toward product innovation, but half its current R&D addresses environmental issues. MacMillan Bloedel splits its efforts evenly between process and product technology. It has made substantial advances through its award-winning breakthrough technology — which produces Parallam, a high-strength composite wood product that competes with construction steel and concrete beams. The company spent 20 years and $150 million developing and testing Parallam, a material three times as strong as natural wood.

Repap, one of the world's largest manufacturers of coated papers, has allocated its substantial R&D investment mainly to the development of Alcell, a breakthrough in pulping technology, and to ongoing research to refine the process technology for coated paper. The Alcell process refines the fragmented wood components into relatively pure fractions suitable for many commercial applications. The early work for the new process was initiated at the University of Pennsylvania. Subsequently, Repap bought the technology, invested in substantial refinements, and in 1989, with federal and provincial financial assistance, successfully started a pilot plant in Newcastle, New Brunswick. Repap has a 50-50 joint venture with a German company, which will have the mandate to build Alcell mills on a turnkey basis worldwide.[20]

There are in Canada three main categories of research and development activity — in-house R&D by the companies, research carried out by cooperative laboratories sponsored by industry and government, and research performed by provincial and federal governments and universities. Some consider the forest-products R&D system in Canada to be more fragmented than that in the United States, Sweden, or Finland, and characterized by less cooperation among organizations, although there is no clear evidence of this.

Industry, Science and Technology Canada estimates that, in 1987, 40 per cent of Canadian forestry and forest-products research was performed by in-house labs, 17 per cent by the three cooperative research laboratories (Feric, Paprican, and Forintek), and 43 per cent by governments and universities (Table 4). In 1988 total estimated R&D in the forestry and forest-products sectors, including R&D by manufacturers of forestry equipment and aircraft to fight forest fires, was $350.6 million. Nearly half was funded by industry and a third by the federal government. Industry and the cooperative research laboratories conducted most R&D, while the federal government performed less than one-fifth (Table 5). Much of the government-funded R&D is in silviculture and is conducted primarily at government-operated laboratories.

Table 4. Canadian forest-products R&D spending (1987)

R&D source	$ million	% of total
In-house labs	105.0	40.3
Institutions		
• Feric	5.1	2.0
• Paprican	24.5	9.4
• Forintek	13.7	5.3
Subtotal	43.3	16.6
Governments and universities		
• Canadian forestry service	75.0	28.8
• Other federal	8.0	3.1
• Provinces	20.0	7.7
• Universities	9.0	3.5
Subtotal	112.0	43.1
Total	260.3	100.0

Source: ISTC estimate

Feric (Forest Engineering Research Institute of Canada) specializes in transportation and logging. Much of its contribution has been in modifying established foreign technology. Paprican (Pulp and Paper Research Institute of Canada) focuses on five areas — fibre supply and quality, chemical pulp, mechanical pulp, papermaking, and paper and paperboard; it also has an educational role. Forintek Canada Corporation is a research institution specializing in solid-wood products. Each provides a useful service to this sector, whether as a technology supplier and developer, a catalyst stimulating technological innovation and application, or a technological bridge promoting adoption and adaptation of best-practice technology.[21]

Government research concentrates on forestry and forest management; the Canadian government has eight regional laboratories and also supports Forintek and Feric. Several universities contribute research in forest management, and some do research on wood-product manufacturing and pulp-and-paper process technology. There are stronger links emerging between the universities, governments, and the three cooperative research institutes in which forest-products firms have an important role.

The forest-products sector is the focus of one of the "centres of excellence" funded in part by the federal government. The research project was organized by Paprican and has a $14.6 million federal government grant, with contributions from the Canadian pulp-and-paper industry that are funnelled through Paprican. This money helps support a four-year program of research into chromophore chemistry, bleaching, pulping, control, and processing at various centres.

Table 5. Total contribution to R&D in forestry (1988) ($ millions)

Sources of funds§	Federal government	Provincial governments	Universities	Industry†	Industrial research institutes‖	Total contribution by reporting agencies
Federal government	59.4	1.0	14.3*	21.3	9.7	105.7#*
Provincial governments	—	29.2	5.5*	5.6*	3.5	43.8
Universities	—	—	7.0*	—	—	7.0*
Industry†	—	—	1.0*	136.3*	28.7	166.0*
Others‡	—	—	1.2*	24.5*	2.4	28.1*
Total intramural research and development	59.4	30.2	29.0*	187.7*	44.3	350.6*

Source: Statistics Canada, Forestry Canada, industrial research institutes

* Estimated
† Includes research and development expenditures by manufacturers of forestry equipment and forest fire-fighting aircraft
‡ May include other Canadian and foreign sources, contracts, and others
§ Intramural expenditures: expenditures for R&D performed within the reporting agency, including work financed by others
‖ Includes Feric, Forintek, and Paprican
\# The total federal government contribution ($105.7 million) may be underestimated. The current reporting methodology does not allow us to clearly indicate the distribution of the federal portion of research and development funding ($9.6 million) under Forest Resource Development Agreements. Part of these funds may already be included under some of the performers.

— Nil

A recent focus of R&D in the sector is on solving increasingly acute pollution problems. Pulp-and-paper mills across Canada use chlorine in their bleaching process, and their effluents include varying amounts of dioxins and furans. The sector has cooperated with governments to determine the extent of pollution and pledged to upgrade all mills to comply with new, tougher pollution standards. There is far from full agreement about detectable toxic effects attributable to organochlorine effluents at the levels below those permitted by the new federal regulations to be implemented after 1993.

Paprican is leading a major new pollution-abatement R&D program; and the federal government, in 1991, pledged up to $25 million to support potentially $60 million of research projects over the five-year life of the program. The sector is responding to heavy environmental pressures, particularly the new regulations in the *Canadian Environmental Protection Act*. The regulations stipulate that by the end of 1993 pulp mills must eliminate from their waste water dioxins and furans from the bleaching process. The federal funding pledge has helped to sustain the private-sector funding

of Paprican at a time when the sector has been heavily battered by the recession and seriously cut its investment in modernization, thereby endangering its future competitiveness.

It is remarkable that this sector, on which so much of Canada's creation of wealth depends, that only two forest-products firms see the need to, and do, conduct in-house solid-wood R&D. One of these, Canfor, founded its research group three years ago when it recognized the potential synergy between the solid-wood and pulp-and-paper sides of its business.

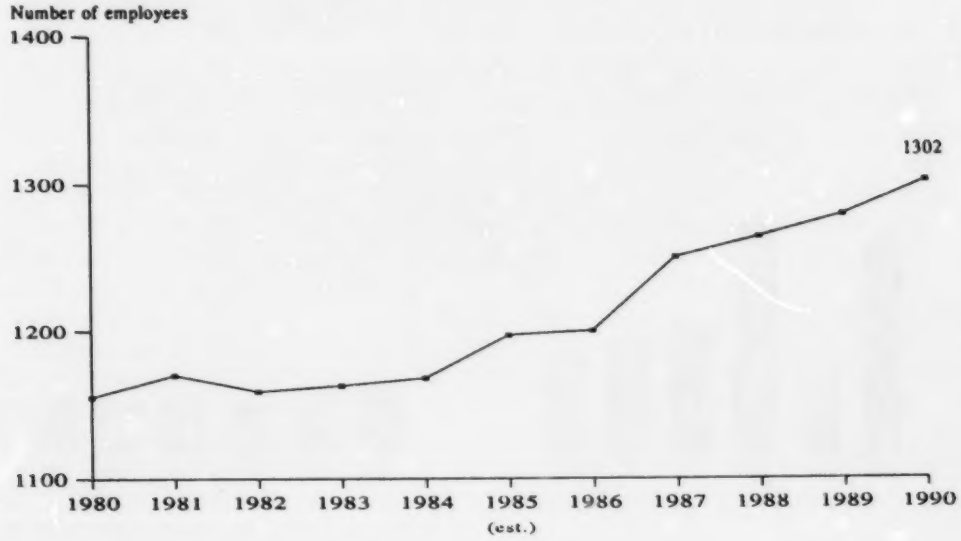
Canada's forest-products R&D is relatively limited, but a measure of its creative capacity is the number of times Canadians have won Sweden's Marcus Wallenberg Prize (the sector's equivalent of the Nobel Prize). Three of the first seven winners were Canadian, including the inventors of Parallam at MacMillan Bloedel. Individual Canadian scientists excel in the R&D system, but the system is weak — though improving — in teamwork and in commercializing new products.

In spite of the R&D activity noted, R&D trends in the Canadian forest-products sector are profoundly disturbing. Between 1980 and 1990, the number of employees doing in-house research among the 13 main Canadian companies performing R&D has fluctuated, but the trend has been to reduce staff — from about 600, 10 years ago, to about 500 now (Figure 8). In the same period, the number of employees doing cooperative research in 10 Canadian labs and universities has gone from about 1150 to 1300 (Figure 9). Canadian wood-products and pulp-and-paper companies increased R&D spending in the late 1980s (Figure 10). R&D as a percentage of sales, however, decreased, particularly in wood-products companies in the mid-1980s (Figure 11). But in late 1990 and early 1991 the sector's economic woes contributed to severe cutbacks in the R&D operations of major firms, such as Canadian Pacific Forest Products, Domtar, and Abitibi-Price. Canadian Pacific Forest Products, for instance, closed its research laboratory, with more than 60 people, in Hawkesbury, Ontario. A vice-president argued that the company was unable to rejuvenate its in-house R&D resources to the point where it could keep pace with changes in cutting-edge technology; the more cost-effective option was to sponsor and purchase R&D from others such as universities and Paprican.[22]

Figure 8. Number of employees doing in-house pulp-and-paper research in 13 Canadian forest-products companies (1980–1990)

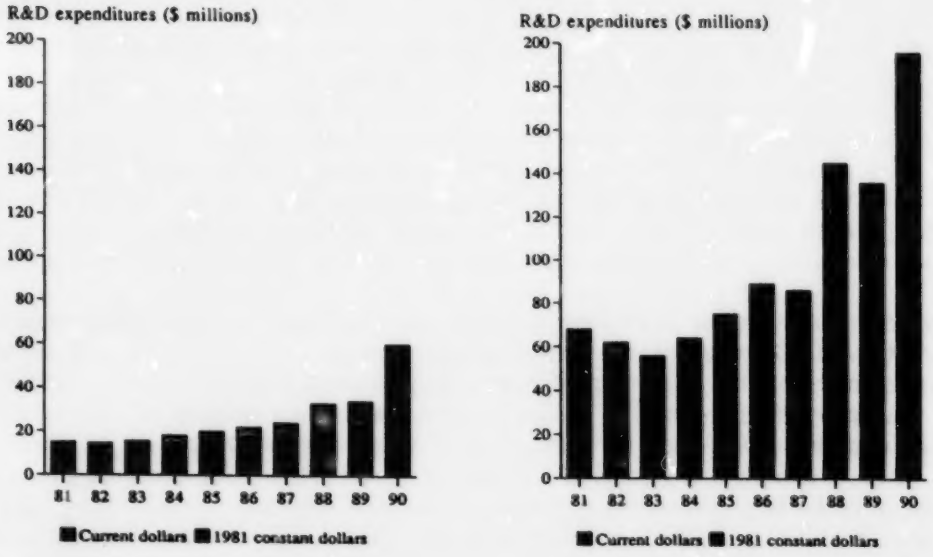
Source: Data collected for the Canadian Pulp and Paper Association

Figure 9. Number of employees doing cooperative pulp-and-paper research in 10 Canadian labs and universities (1980–1990)



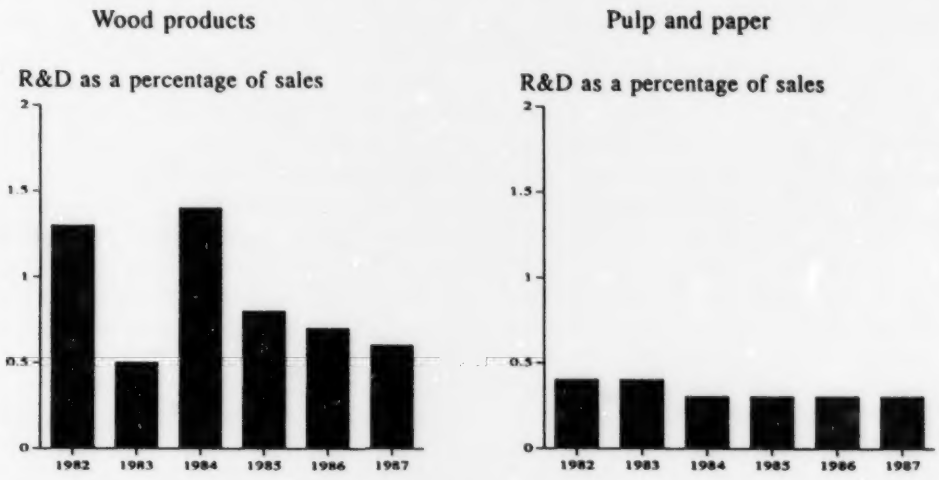
Source: Data collected for the Canadian Pulp and Paper Association

Figure 10. Total intramural R&D expenditures in Canadian forest-products companies (1981–1990)



Source: Statistics Canada 88-202, adjusted for improved coverage and response

Figure 11. Total intramural R&D expenditures by Canadian forest-products firms as a percentage of sales



Source: Statistics Canada 88-202

High interest rates and a high dollar have taken their toll. Under current conditions there is more incentive for Canadian firms to invest south of the border. The incentive will be all the greater if wages become less competitive. When the economy begins to pick up again, this sector will not be well poised to face emerging conditions, unless it responds to environmental concerns and recycling requirements, and unless the current cost disadvantages compared with mills in other regions of the world are diminished.

Opportunities and Challenges for the Canadian Sector

Enhancing Technical Competence

The Canadian forest-products sector must enhance its technical competence and ability to innovate. Executives in the sector agree that the low R&D performance and technical ability are concerns.

To date, Canada has remained competitive mainly by buying and adapting new technologies from other countries, doing a modest amount of in-house research, and using the results of research performed in the cooperative laboratories.[23] But, as one executive observes: "Buying technology from suppliers does not give us any technological advantage." Such an advantage will be needed to develop new markets, especially in the Pacific Rim and Europe, and to make inroads into new North American markets for higher value-added wood products.

Canadian firms must become more market sensitive — they must encourage and respond to demands for better quality and more customized products. These cannot be fully and suitably developed from research and technology available to everybody. Dependence on machinery and equipment suppliers and cooperative research, with minimal in-house proprietary research, may stifle productivity and reduce sales opportunities, market share, and profits. Canadian firms need greater technological capability, even if only to buy and use state-of-the-art technology intelligently in the short term. A shortfall in the technical competence of operators only makes the introduction of modern machinery more risky and potentially less effective.

Technology and Market Opportunities

Wood Products

The lumber industry is not likely to undergo any fundamental change in the foreseeable future. Major gains have already taken place in sawmill productivity. We can expect further refinement in areas such as lumber grading and thin-kerf sawing. Canadian producers have adapted process improvements originated in Europe to help themselves remain competitive. However, lower-cost fibre producers, notably Brazil and Chile, also have access to this technology, and we can expect increasing price competition from them. Any resulting reduced prices and limits to domestic cost reductions may lead to lower profitability for the large, integrated mills and closure of the smaller, uncompetitive ones.

It is a priority for Canadian wood-products manufacturers to develop more innovative technologies and to design and market new lumber and panel products — for example, reconstituted wood products such as MDF-faced strandboard and Parallam. As Dr. K.A. French, Forintek's president, observes: "Although productivity studies will continue to be important, we will place increasingly greater stress on technologies that help wood compete more successfully with non-wood materials."

Canada could become a leader in the development, production, and marketing of reconstituted composite products if Canadian firms were prepared to invest in the necessary R&D — but they appear reluctant to do so. The main opportunity appears to be in the light industrial and commercial construction market for wood, which in North America may be as high as $5 billion annually. However, realizing this opportunity will require more research into wood-structure designs. In Western Europe the only academic effort in this field is at Lausanne University in Switzerland. As the producers and users of wood substitutes increasingly emphasize performance and reliability in design, so also must the producers of wood materials. Canadian producers should consider stimulating and supporting a Canadian academic initiative in this area, perhaps at the University of British Columbia.

Market Pulp

Worldwide, this sector is moving toward high-yield pulping processes and the use of hardwoods. The commercialization of multistage bleaching and the increase in CTMP will blur the distinction between wood-containing and wood-free pulps. Oxygen bleaching will replace some chlorine bleaching in response to environmental pressures. Nevertheless, chemical pulps will continue to be important for strength (reinforcement for recycled fibre and lightweight mechanical papers), permanence (printing grades), absorptivity (personal products), and purity (personal products and food grades).

Canadian firms have done well in the past decade mainly in adopting and adapting CTMP technology. This technology requires a great deal of power and is thus well suited for this country, with its relatively cheap energy. The Canadian sector now has 59 per cent of world capacity for bleached CTMP market pulp and must continue investing heavily in plants and research to maintain its leadership position. The national centres of excellence project previously referred to is an excellent example of a cooperative project that should help Canadian firms who are trying to build a competitive edge by applying the results of the R&D.

The market for pulp-and-paper products is diversifying and focusing more on pulp grades for specific end uses. Concentrating on making production more efficient will no longer be enough to satisfy the different needs of customers. Forest-products firms will increasingly have to sponsor or conduct R&D in concert with their marketing strategies. The proliferation of pulp grades for specific users will require a higher level of proprietary R&D by individual companies.

Newsprint

Canada continues to maintain a cost advantage because of its inexpensive energy resources. But it is beginning to lose its competitive edge on fibre cost, which propelled this country into the first rank in newsprint production. Thus, the arrival of the TMP and CTMP technologies, which use less fibre but more energy, is important. Nonetheless, the many small, old, and inefficient newsprint mills in Ontario and Quebec will continue to face competitive pressure, including competition from developing nations and environmental pressures.

As well, new printing technology and increased colour advertising require better grades of newsprint. The result is a demand for more and sharply differentiated grades of paper. This demand is expected to grow and lead to new speciality paper markets.

Another factor of growing importance is the demand for recycled paper to make newsprint. This will drastically cut the rate of increase in the demand for trees and energy. The advent of newsprint recycling introduces a lower-cost, less energy-intensive fibre source, to the extent that supply is available. Recent state, county, and city legislation in the United States is forcing newspaper publishers to use recycled paper. This action has potentially far-reaching implications for Canadian newsprint producers in western, central, and eastern Canada. Canadian demand for papers to recycle is expected to grow nearly sevenfold from 1989 to 1993. This poses a problem for Canadian producers, in that they are close to their sources of virgin fibre but not so close to sources of waste paper. It has been estimated that it costs Canadian producers U.S.$485 to make one tonne of recycled newsprint, compared with U.S.$407 for papermakers in the southern United States.[24] This situation might change, however, depending on sludge disposal costs. Only one of the nine mills in North America that make recycled newsprint is in Canada, although Canada is slated for significant investment in de-inking plants over the next two years. The economic impact of enforced use of recycled fibre on Canadian newsprint mills will depend largely on their location and specific circumstances. The same is true for U.S. mills. The challenge to mills farthest from the sources of waste paper, and those having the highest sludge disposal costs, will be to switch to better grades of newsprint or to markets that still accept virgin fibre.

Although the Canadian industry has invested heavily in modern plants in the last 10 years, it is not a technological leader nor is it, in many cases, close to achieving state-of-the-art production. It will be hard-pressed to catch up technologically with the leaders in areas such as de-inking and recycling technology, although companies such as Quebec and Ontario Paper, Noranda Forest, and Stone Consolidated are well advanced. One way to catch up, and at the same time get access to Asian markets, may be through joint ventures with Japanese paper companies.

Printing and Writing Paper

P&W paper, the fastest-growing segment of the market for forest products, is one of the highest value-added segments. The global market is now more than 50 million tonnes, and growth in the next 10 years is expected to require about 250 new machines globally. Office automation and new advertising techniques are driving this growth. The former classifications of freesheet, groundwood, coated, and uncoated papers are giving way, at least for Canadian producers, to an increasing differentiation in higher-quality grades.

Although world export trade in P&W papers has been modest, compared with trade in pulp, lumber, and newsprint, it is likely to grow. Canada has an excellent opportunity to move into this promising new market, helped by the Free Trade Agreement with the United States.

TMP and CTMP pulps will likely play an increasingly important role in P&W papers. However, many of our small newsprint machines are being squeezed out of production by competition from larger and faster newsprint machines. The challenge is how to select and pay for new machines to produce higher value-added papers for specialty markets.

At present, Canada lags behind the United States in modern P&W paper installations, despite some recent world-capacity additions. Only 50 per cent of Canadian P&W operations are integrated, against 75 per cent in the United States. Integration has advantages in cost and quality. Many of the non-integrated kraft mills, now providing market pulp for export, may need to be converted to integrated operation.

The most technologically advanced papermakers in the world are the Germans and Japanese, who have consistently been leaders in R&D. The Japanese have not been net exporters of P&W papers, but the Germans have recently been exporting to the United States. And U.S. producers have recently been adding large-scale machines.

In this subsector, there is less distinction between product and process technological innovation, insofar as new technology for paper machines can lead to new grades of paper and paperboard. New coatings for speciality paper, for instance, can contribute to new high-value products. Despite the potential benefits of technological innovation, however, few Canadian firms have invested in the necessary R&D.

Developing P&W paper has always required a high level of R&D, and now more than ever the marketplace is demanding higher quality at lower cost. Aggressively entering this market may require more of a systems approach to innovation: working from silviculture through pulping, papermaking, and product development, and closely linking marketing back to R&D. The market will become more fragmented; with smaller and smaller niches, it is likely to prove harder to compete simply by buying technology. In-house R&D, plugged into consumer demand and aided by government and cooperative research efforts, will be vital to success. It will be equally vital to work closely with the merchants who supply the high value-added paper market. In the United States and Europe those merchants are mostly captive to the larger domestic producers, a factor that is a big impediment for Canadian firms trying to enter the market.

A Daunting Challenge

Executives of Canada's forest-products firms face a daunting challenge in reshaping their firms. They have to improve on the performance of the past decade in which the average return on assets was below not only that of competitors in the United States but also the returns on risk-free Canada Savings Bonds.[25] Much of the thrust of this report is to urge the sector to help itself in developing new products and conducting in-house research. But there is also an important role for governments, one with many facets. Provincial governments own and manage most of the forests and, therefore, supply the fibre. Governments also have a responsibility for the economic wellbeing and environmental health of Canada, both of which are heavily affected by the performance of this sector.

Government shares some responsibility with private firms to ensure a continuing supply of high-quality fibre to the forest-products industry. With 453 million hectares of forest, roughly 10 per cent of the world's total, Canada has satisfied the needs of its forest-products sector from vast amounts of first-growth timber and natural regeneration. This situation has come to an end. One of the greatest needs of the sector is enhanced fibre production to enable greater output from a given amount of forest land, shorter haul distances, and greater availability.

It has been pointed out repeatedly in the last two decades that Canada must do more to ensure an adequate supply of wood that can be economically harvested.[26] In response, the federal government has created a department of forestry, and the federal and provincial governments have initiated more-aggressive replanting programs. Also the forestry laboratories of federal and provincial governments are working to improve methods of silviculture, and Canada is becoming one of several world leaders in the application to forestry of biotechnology. The applications use superior, genetically engineered seedlings to produce higher yields, better quality, and faster growth. Canada is also well respected for its research into forest fire and pest protection.

However, relatively few Canadian foresters consider that their own province is doing a good, let alone an excellent, job in forest management.[27] The system of forest administration, designed to provide a perpetual supply of industrial timber as new, managed forests mature, is increasingly viewed to be failing. And it is not well supported by the prevailing level of forest research. As the House of Commons Standing Committee on Forestry and Fisheries has argued, in the new era of sustainable forestry development, if there is to be any real hope of maintaining and expanding present uses of the forests, as well as sustaining their environmental values and capabilities, forest research must not only reflect these goals, but it must also lead the way toward them.[28] Moreover, effective management requires a national vision about the future of our forests, a vision that can provide guidance to those who plan and administer the forest to satisfy and reconcile varied and frequently competing uses and values. For British Columbia, the B.C. Forest Resources Commission has attempted to provide such a vision, embracing the ethic of enhanced stewardship and supporting intensive, integrated management for the largest forest land base possible.[29]

There is a need to create a cohesive research network, with more coordination and collaboration between the many research facilities. In addition, governments in Canada should do more to improve forest management and attempt to resolve disputes such as those over aboriginal land claims, those between forest managers and ecologists over vanishing old-growth forests, and those between forest managers and environmentalists over clear-cutting practices.[30] Governments should encourage more research on forest ecosystems, to strengthen national commitment to replanting and to produce more highly trained foresters. More fundamentally, the time is right to institute new tenure arrangements between the provinces and the logging companies. New arrangements would improve stewardship of the forest resource and better support its diverse and competing uses.[31] Firms have varying responsibilities for forest management, depending on the province and type of tenure.

Forestry Canada's studies on Canada's long-term timber supply are controversial. They suggest that there are adequate timber supplies to support current levels of logging for the next 30 to 60 years. Beyond that the timber supply is difficult to estimate.[32] Complicating the issue of supply and demand is the considerable difference in the demand for a particular quality of material for specific uses; the capacity of silviculture, reforestation, and technological developments to minimize supply problems; and, a point of serious current concern for both business and government, the continuing and increasing threat to forest-sector jobs posed by a potential boycott of Canadian forest products in Europe (driven by environmental groups opposed to some Canadian forestry practices). Implementing the forestry provisions outlined in Canada's Green Plan would be a major contribution to removing the problem image and practices that are helping create a European boycott. The forestry provisions could also help demonstrate whether selective harvesting might be an economically viable replacement for clear cutting.[33] Also, a step in the right direction would be provincial requirements for independent environmental audits each year, to establish whether governments and industry are managing the forests responsibly.

In reforestation, the federal government is caught in an unenviable position. It is under pressure to trim its expenditures, including those in support of the troubled timber industry, while avoiding accusations of stepping on provincial toes as it attempts to lever provincial support in joint reforestation agreements. The move from relying on natural regeneration to planting and managing a second-growth forest will take decades, but at least the argument now is not whether to make the transition, but how. The argument could hardly be more critical given that forests make up fully half the Canadian landscape, an area three times the size of Europe, and are central to our national identity. And Canada must fulfil its obligations to demonstrate international leadership in forest management, to help maintain the stability of global ecosystems and help preserve biological diversity.

Conclusion

The Canadian forest-products sector is a success in terms of its contributions to employment, gross domestic product, and exports. The sector has proved highly competitive in the past decade, but it also produced a poor return on assets. It now faces some daunting challenges to improve performance. The recent recession and high Canadian dollar have badly jolted it and hurt its competitiveness. High interest rates and fast-changing environmental and market conditions also now severely test its resilience. There will be no return to the status quo. Continued reliance on traditional management will no longer do.

The sector must improve its status and shake its image as a polluter and destroyer of forests. It must be seen as a modern sector, creating wealth for Canadians and using technology to achieve major goals in sustainable development. In view of the rapidity of technological change, Canadian firms should ensure they have systematic, and perhaps cooperative, approaches for monitoring and evaluating technological developments in other countries. They should also examine emerging technologies in other sectors that may be useful to them. The development of monitoring functions might help improve the linkages between firms and the cooperative and university research institutions.

The sector's technology strategy has been primarily adopt and adapt. But there are notable exceptions of firms developing breakthrough technologies, and there are major creative strengths in the R&D performed by the cooperative R&D organizations. To maintain or improve competitiveness and fulfil the sector's potential to grasp global market opportunities, the sector's senior executives, several of them new, must strive to improve technical competence and R&D capabilities in their core business. The need to attend to technological matters and customer satisfaction will only be reinforced by a continued high Canadian dollar.

Governments can also contribute to the sector's competitiveness, particularly by working to ameliorate or resolve the problems of fibre supply, and to make major improvements in education and training.

Appendix: Framework for Technology Strategies

As part of the methodology for analysing each sector, the Science Council of Canada sought whenever possible to assess company technology strategies according to the following framework:

	adopt and adapt	innovation	breakthrough
product			
process			

Strategy Classes

Adopt and Adapt: Acquire a technology and adapt it to serve as a competitive platform.

Innovation: Incrementally improve on winning technology to get greater market share or maintain competitive edge.

Breakthrough: Seek to create a discontinuity in the marketplace, thereby leaping ahead of the competition.

The company case studies generally looked for at least seven key dynamics influencing a company's technology strategy:

- three internal dynamics:
  - competitive position,
  - capacity for innovation, and
  - strategy and vision; and
- four external dynamics:
  - customer demands,
  - competitive rivalry,
  - supply condition, and
  - available technology.

The methodology also incorporated essentially a three-step process for each sector. In the first step one or more contractors analysed the main elements in the competitive and R&D performance of the Canadian sector and its leading foreign competitors. The second step included evaluation of the contract report(s), discussion with contractors and other experts, additional in-house research, and preparation of a draft Council report. In the third step, external reviewers commented on one or more drafts of the Council report, which were then revised and refined as required, drawing on the advice of the liaison person for that sector on the Steering Committee (see Acknowledgements). For some sectors, the third step also involved several external reviewers in a small workshop, one part of which

helped define some elements of a potential action plan for the sector. The report was then submitted for final approval to the Executive Committee of the Science Council, before being forwarded to Industry, Science and Technology Canada.

Notes

1. R. Hayter, *Technology and the Canadian Forest-Product Industries*, Science Council of Canada, Background Study 54 (Ottawa: Supply and Services Canada, 1988). See also Science Council of Canada, *A Sectoral Approach to Innovation: The Case of the Forest-Product Industries* (Ottawa: Science Council of Canada, 1987), 13. "Global demand for bulk forest-product commodities is growing less rapidly than in the past and in some segments is even declining. Population growth in the rich industrialized countries has slowed considerably and continued income growth has not generated a proportionate rise in forest-product expenditures."

2. Woodbridge, Reed and Associates, *Strategic Analysis*, vol. 1 of *Canada's Forest Industry, The Next Twenty Years: Prospects and Priorities* (Ottawa: Canadian Forestry Service, 1988), 50-56.

3. Ibid., 57-62.

4. Ibid., 62-69.

5. Woodbridge, Reed and Associates, *World Demand/Supply*, vol. 2 of *Canada's Forest Industry, The Next Twenty Years: Prospects and Priorities* (Ottawa: Canadian Forestry Service, 1988), 53-58.

6. Woodbridge, Reed and Associates, *Strategic Analysis*, op. cit., 53-58.

7. Ibid., 62-64.

8. Ibid., 65.

9. Ibid., 65-69.

10. Ibid., 8-18.

11. Ibid., 194.

12. Canada Consulting Cresap, "The Forest Industry," contract report for Science Council of Canada, 1991 (unpublished), 45.

13. Ibid., 50.

14. Ibid., 56.

15. Ibid., 51.

16. *Technical Capability Comparison: Pulp and Paper Industry, Canada, Sweden, Finland, Norway and Germany* (Montréal: Canadian Pulp and Paper Association, 1988).

17. N. Rosenberg et al., "Understanding the Adoption of New Technology in the Forest Products Industry," *Forest Products Journal* 450, no. 10 (October 1990): 15-22.

18. Hayter, op. cit.

19. Canada Consulting Cresap, op. cit., 38-68.

20. Ibid.

21. Hayter, op. cit.

22. See *Research Money*, 6 March 1991, 7. Emphasis on the need for increased in-house R&D is not a panacea. There have to be strong links between corporate strategy, market opportunity, firm capability, and technology potential. As R.B. Loughlan in *The Forestry Chronicle*, April 1989, 154, commented: "Years of incompetent research management have spread an odour that lingers. Complaints heard from industry executives about research programs over the years are: little apparent targetting of goals, no coordination of projects, overlapping of efforts, few results, poor dissemination of results, especially to those who could use them, funding of frivolous or unnecessary projects, not enough accounting for dollars spent, and not enough spending control."

23. Hayter, op. cit. See also Forest Industry Machinery Task Force Report, *Synergy: A Bonus from Cooperation* (Ottawa: Industry, Science and Technology Canada, 1988).

24. The estimates are by J. Duncanson, Sanwa McCarthy Securities Ltd., as quoted by B. McKenna, "Newsprint Makes Struggle to Recycle," *Globe and Mail*, 13 February 1991. For a different perspective, see K.V. Pesonen, "Recycled vs. Virgin-Energy and Manufacturing Cost Differentials: Four Hypothetical Case Studies," in *TAPPI Symposium Notes*, Focus 95+, 19-21 March (1991), 251-65.

25. Price Waterhouse, *The Forest Industry in British Columbia, 1990* (Vancouver, May 1991) 4.

26. See, for instance, Science Council of Canada, *Canada's Threatened Forests*, 1983.

27. Forestry Canada, *The State of Forestry in Canada: 1990 Report to Parliament* (Ottawa: Minister of Supply and Services Canada, 1991), 30.

28. Standing Committee on Forestry and Fisheries, House of Commons, *Forests of Canada: The Federal Role* (Hull: Queen's Printer for Canada, 1990).

29. British Columbia, Forest Resources Commission, *The Future of Our Forests* (Victoria, 1991).

30. The report of the Standing Committee on Forestry and Fisheries provides recommendations on research priorities and how to proceed. See also L. Dayton, "New Life for Old Forest," *New Scientist*, 13 October 1990, 25-29.

31. The B.C. forest industry, for instance, believes that converting volume-based tenures into area-based agreements would mean better management for several forest resources. See Council of Forest Industries of B.C. et al., *A Vision of B.C. Forests in the 21st Century* (Vancouver, February 1991).

32. Forestry Canada, op. cit., 28. For an alternative outlook, see Reed, F.L.C., "Canada's Timber Situation in 2050," in D.G. Brand, ed., *Canada's Timber Resources*, Forestry Canada, Petawawa National Forestry Institute, Information Report P1-x-101, 1991.

33. Environment Canada, *Canada's Green Plan* (Ottawa: Minister of Supply and Services Canada, 1990), 61-65.